CLAIMS

1. A solid-state imaging device having an integrated array of a plurality of pixels, each pixel comprising:

a photodiode for receiving light and generating photoelectric charges;

a transfer transistor for transferring the photoelectric charges; and

a storage capacitor element coupled to the photodiode at least through the transfer transistor for accumulating, at least through the transfer transistor, the photoelectric charges overflowing from the photodiode during accumulating operation.

2. The solid-state imaging device according to claim 1, further comprising between the transfer transistor and the storage capacitor element:

a floating region to which the photoelectric charges are transferred via the transfer transistor; and

a storage transistor operative to couple or split potentials of the floating region and the storage capacitor element.

3. The solid-state imaging device according to claim 2, further comprising:

a reset transistor coupled to the floating region for discharging the photoelectric charges of the floating region;

an amplifier transistor for amplifying the photoelectric charges in the floating region for conversion to a voltage signal; and

a selection transistor coupled to the amplifier transistor for selecting the pixel.

4. The solid-state imaging device according to claim 3, comprising:

a logarithmic conversion circuit for executing logarithmic conversion of the photoelectric charges accumulated in the storage capacitor element for readout.

5. The solid-state imaging device according to claim 3, comprising:

a logarithmic conversion circuit for executing logarithmic conversion of the photoelectric charges overflowing from the photodiode for accumulation in the storage capacitor element.

6. The solid-state imaging device according to claim 2, further comprising:

a reset transistor coupled to a junction between the storage capacitor element and the storage transistor for discharging the photoelectric charges in the storage capacitor element and the floating region;

an amplifier transistor for amplifying the photoelectric charges in the floating region for conversion to a voltage signal; and

a selection transistor coupled to the amplifier transistor for selecting the pixel.

7. The solid-state imaging device according to claim 1, wherein:

the transfer transistor is of a buried channel type having such a semiconductor layer of the same conductive type as that of a channel of the transfer transistor that is formed in a surface of a substrate in which the transfer transistor is formed or in an area of the substrate from a vicinity of the surface down to a predetermined depth.

8. The solid-state imaging device according to claim 1, wherein:

the transfer transistor has such a semiconductor layer that is formed in an area in a predetermined depth of a substrate in which the transfer transistor is formed and is of the same conductive type as that of a channel of the transfer transistor, the semiconductor layer reducing a barrier for punch-through of the transfer transistor.

9. The solid-state imaging device according to claim 1, wherein:

the storage capacitor element comprises;

a semiconductor region serving as a lower electrode and formed in a

surface area of a semiconductor substrate in which the solid-state imaging device is formed,

a capacitor insulation film formed on the semiconductor region, and

an upper electrode formed on the capacitor insulation film.

10. The solid-state imaging device according to claim 1, wherein:

the storage capacitor element comprises;

a lower electrode formed on a substrate in which the solid-state imaging device is formed,

a capacitor insulation film formed on the lower electrode, and

an upper electrode formed on the capacitor insulation film.

11. The solid-state imaging device according to claim 1, wherein:

the storage capacitor element comprises;

a semiconductor region formed in an inner wall of a trench formed in a semiconductor substrate in which the solid-state imaging device is formed,

a capacitor insulation film covering the inner wall of the trench, and

an upper electrode formed by burying the trench via the capacitor insulation film.

12. The solid-state imaging device according to claim 1, wherein:

the storage capacitor element is comprised of a first conductive type semiconductor region and a second conductive type semiconductor region in junction with the first conductive type semiconductor region, both being buried in a semiconductor substrate in which the solid-state imaging device is formed.

13. The solid-state imaging device according to claim 1;

wherein the solid-state imaging device is formed in an SOI (Semiconductor on Insulator) substrate in which a semiconductor layer is formed via an insulation layer on a semiconductor substrate, and

wherein the storage capacitor element utilizes an insulation film capacitance between the semiconductor substrate and the semiconductor layer,

both opposing each other via the insulation film.

14. The solid-state imaging device according to claim 3, further comprising:

noise canceling means taking a difference between a voltage signal resulting from the photoelectric charges transferred to the floating region or the floating region and the storage capacitor element, and a voltage signal at a reset level of the floating region or the floating region and the storage capacitor element.

15. The solid-state imaging device according to claim 14, further comprising:

storage means for storing a voltage signal at a reset level of the floating region and the storage capacitor element.

16. The solid-state imaging device according to claim 6, further comprising:

noise cancel means taking a difference between a voltage signal resulting from the photoelectric charges transferred to the floating region and a voltage signal at a level prior to the transfer of the floating region.

17. The solid-state imaging device according to claim 6, further comprising:

noise cancel means taking a difference between a voltage signal resulting from the photoelectric charges transferred to the floating region and the storage capacitor element and a voltage signal at a reset level of the floating region and the storage capacitor element.

18. The solid-state imaging device according to claim 17, further comprising:

storage means for storing a voltage signal at a reset level of the floating region and the storage capacitor element.

19. The solid-state imaging device according to claim 1, wherein:

a first charge-coupled transfer path for transferring the photoelectric charges of the photodiode is coupled to the photodiode; and

the storage capacitor element is coupled between adjacent pixels to form a second charge-coupled transfer path for transferring the photoelectric charges of the storage capacitor element independently of the first charge-coupled transfer path.

20. The solid-state imaging device according to claim 1, further comprising:

a charge-coupled transfer path coupled to the photodiode for transferring the photoelectric charges of the photodiode;

a reset transistor coupled to the storage capacitor element for discharging the photoelectric charges of the storage capacitor element;

an amplifier transistor for amplifying the photoelectric charges of the storage capacitor element and converting to a voltage signal; and

a selection transistor coupled to the amplifier transistor for selecting the pixel.

21. The solid-state imaging device according to any one of claims 1 to 20, wherein:

the pixel comprises a transistor of an n-channel MOS transistor.

22. The solid-state imaging device according to any one of claims 1 to 20, wherein:

the pixel comprises a transistor of a p-channel MOS transistor.

23. A line sensor having a plurality of pixels integrated in a linear arrangement, each pixel comprising:

a photodiode for receiving light and generating photoelectric charges;

a transfer transistor for transferring the photoelectric charges; and

a storage capacitor element coupled to the photodiode at least through

the transfer transistor for accumulating the photoelectric charges overflowing from the photodiode at least through the transfer transistor during accumulating operation.

24. An optical sensor comprising:

a photodiode for receiving light and generating photoelectric charges;

a transfer transistor for transferring the photoelectric charges; and

a storage capacitor element coupled to the photodiode at least through the transfer transistor for accumulating the photoelectric charges overflowing from the photodiode at least through the transfer transistor during accumulating operation.

25. A method of operating a solid-state imaging device having an integrated array of a plurality of pixels, each pixel having a photodiode for receiving light and generating photoelectric charges, a transfer transistor for transferring the photoelectric charges, a storage transistor, a floating region coupled to the photodiode via the transfer transistor, and a storage capacitor element for accumulating photoelectric charges overflowing from the photodiode via the transfer transistor and the storage transistor during an accumulating operation, the storage transistor controllably coupling or splitting potentials of the storage capacitor element and the floating region, the operating method comprising the steps of:

turning off the transfer transistor and turning on the storage transistor for discharging the photoelectric charges of the floating region and the storage capacitor element, prior to accumulating charges;

reading out a voltage signal at a reset level of the floating region and the storage capacitor element;

accumulating, in the photodiode, pre-saturated charges among the photoelectric charges generated in the photodiode and accumulating, in the floating region and the storage capacitor element, supersaturated charges

overflowing from the photodiode;

turning off the storage transistor to split potentials of the floating region and the storage capacitor element and discharging the photoelectric charges in the floating region;

reading out a voltage signal at a reset level of the floating region;

turning on the transfer transistor so as to transfer the pre-saturated charges to the floating region and reading out a voltage signal of the pre-saturated charges; and

turning on the storage transistor to couple the potentials of the floating region and the storage capacitor element for mixing the pre-saturated charges and the supersaturated charges and reading out a voltage signal of a sum of the pre-saturated charges and the supersaturated charges.

26. The method of operating the imaging device according to claim 25, further comprising:

canceling noise of a voltage signal of the pre-saturated charges by taking a difference between a voltage signal of the pre-saturated charges and a voltage signal at a reset level of the floating region;

canceling noise of a voltage signal of a sum of the pre-saturated charges and the supersaturated charges by taking a difference between the voltage signal of the sum of the pre-saturated charges and the supersaturated charges and a voltage signal at a reset level of the floating region and the storage capacitor element;

adjusting a gain of the voltage signal of the sum of the pre-saturated charges and the supersaturated charges so as to make the gain substantially the same as a gain of the voltage signal of the pre-saturated charges; and

selecting either one of the noise-cancelled voltage signal of the pre-saturated charges and the noise-cancelled voltage signal of the sum of the pre-saturated charges and the supersaturated charges by comparing with a

reference voltage.

27. The method of operating the imaging device according to claim 25, wherein:

the step of accumulating in the photodiode the pre-saturated charges among photoelectric charges generated in the photodiode and accumulating in the floating region and the storage capacitor element the supersaturated charges overflowing from the photodiode comprises the steps of;

adjusting the potential of the transfer transistor to a level for completely turning off the transfer transistor or a level lower than that level.

28. A method of operating a solid-state imaging device having an integrated array of a plurality of pixels, each pixel having a photodiode for receiving light and generating photoelectric charges, a transfer transistor for transferring the photoelectric charges, a storage transistor, a floating region coupled to the photodiode via the transfer transistor, and a storage capacitor element accumulating photoelectric charges overflowing from the photodiode via the transfer transistor and the storage transistor during an accumulating operation, the storage transistor controllably coupling or splitting potentials of the floating region and the storage capacitor element, the operating method comprising:

turning off the transfer transistor and turning on the storage transistor for discharging the photoelectric charges of the floating region and the storage capacitor element, prior to accumulating charges;

reading out a voltage signal at a reset level of the floating region and the storage capacitor element;

accumulating in the photodiode pre-saturated charges among the photoelectric charges generated in the photodiode and accumulating in the floating region and the storage capacitor element supersaturated charges overflowing from the photodiode;

turning off the storage transistor to split potentials of the floating region and the storage capacitor element and reading out a voltage signal at a pre-transfer level of the pre-saturated charges in the floating region;

turning on the transfer transistor for transferring the pre-saturated charges to the floating region and reading out a voltage signal at a post-transfer level of the pre-saturated charges and,

turning on the storage transistor to couple the potentials of the floating region and the storage capacitor element for mixing the pre-saturated charges and the supersaturated charges and reading out a voltage signal of a sum of the pre-saturated charges and the supersaturated charges.

29. The method of operating the imaging device according to claim 28, further comprising the steps of:

canceling noise of a voltage signal of the pre-saturated charges by taking a difference between a voltage signal at the post-transfer level of the pre-saturated charges and a voltage signal at the pre-transfer level of the pre-saturated charges;

canceling noise of a voltage signal of a sum of the pre-saturated charges and the supersaturated charges by taking a difference between the voltage signal of the sum of the pre-saturated charges and the supersaturated charges and a voltage signal at a reset level of the floating region and the storage capacitor element;

adjusting a gain of the voltage signal of the sum of the pre-saturated charges and the supersaturated charges so as to make the gain substantially the same as a gain of the voltage signal of the pre-saturated charges; and

selecting either one of the noise-cancelled voltage signal of the pre-saturated charges and the noise-cancelled voltage signal of the sum of the pre-saturated charges and the supersaturated charges by comparing with a reference voltage.

30. The method of operating the imaging device according to claim 28, wherein:

the step of accumulating in the photodiode pre-saturated charges among photoelectric charges generated in the photodiode and accumulating, in the floating region and the storage capacitor element, supersaturated charges overflowing from the photodiode comprises the steps of;

adjusting the potential of the transfer transistor to a level for completely turning off the transfer transistor or a level lower than that level.